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NORMAL INCIDENCE BOTTOM REFLECTION MEASUREMENTS IN ATLANTIC ARE--ETC(U)
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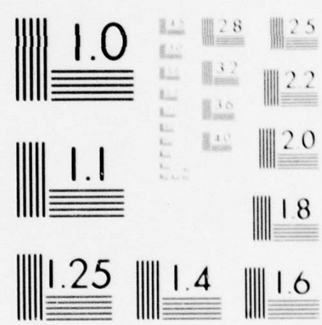

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ABSTRACT

Normal incidence 12-kc bottom reflection loss measurements were made from the USS PREVAIL (AGS-20) at 15 stations in an area extending from 32°00' to 34°00'N and 71°00' to 73°00'W. The area lies along the northwestern edge of the Hatteras Abyssal Plain. These measurements were made with an AN/UQN-1 echo sounder and the REMPAC reflectivity system. Mean values of bottom reflection loss, computed for each station, ranged from a low of 14 db to a high of 26 db. The mean reflection loss for the area was 19.9 db. The possibility of using a three-layer model to explain and predict bottom reflection loss was investigated.

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Table of Contents and Page 9 - Title for Figure 6 should read "Bottom Reflection Loss Versus Thickness of Layer 2"

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NORMAL INCIDENCE BOTTOM REFLECTION MEASUREMENTS IN ATLANTIC AREA C-1

INTRODUCTION

Normal incidence 12-kc bottom reflection loss measurements were made aboard the USS PREVAIL (AGS-20) with an AN/UQN-1 depth sounder and the REMPAC[1,2] reflectivity system during March 1963.

A calibrated towed transducer was used in conjunction with the depth sounder at 11 of the 15 stations. The ship's hull transducer was used on the remaining 4 stations. It became necessary to switch to the hull transducer when the towed transducer became inoperative during rough seas. As a safeguard against such a mishap and since it was not possible to actually calibrate the hull transducer, comparative reflection loss measurements were made with the calibrated towed transducer and the hull transducer. These measurements, made in selected areas, showed the reflection loss values obtained with the hull transducer to average 5.3 db less than the losses obtained with the towed transducer. It was therefore assumed that the transmitting response and the receiving response of the hull transducer differed from the towed transducer by this amount.

INSTRUMENTATION

The depth sounder operated on the 6,000-fathom scale and transmitted a 150-millisecond pulse every 30 seconds. The transmitting response of the towed transducer was 60.1 db//microbar/volt at 1 meter, and the receiving response was -70 db//volt/microbar. The beam width of the towed transducer was 60 degrees at the 10-db down points. The rms voltage to the towed transducer was 120 volts, and the source level was 101.7 db//microbar at 1 yard.

DATA COLLECTION AND ANALYSIS

A reflection loss measurement was made every 30 seconds during a 15-minute period at each of the 15 stations shown in Figure 1. The measurements were made while the ship was on station and subject to local drift conditions. The mean and standard deviation of bottom reflection loss for each station are presented in Table 1.

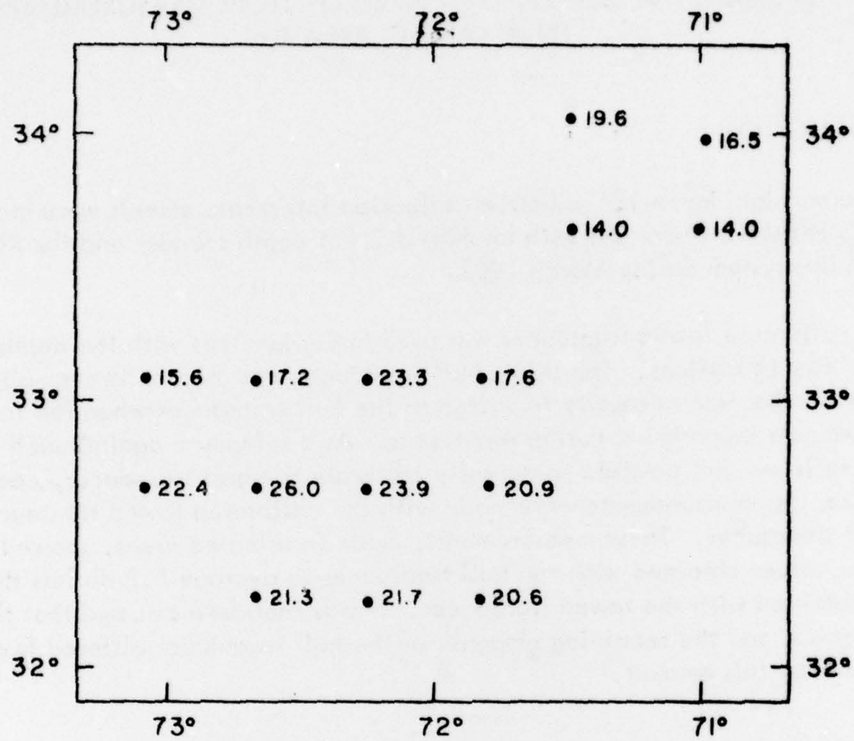

FIGURE 1 BOTTOM REFLECTION LOSS (db)

Bottom loss, based on the absolute calibration, was determined from the following equation: Mean Reflection Loss = Source Level - Propagation Loss + Receiving Response + Receiver Gain - Recorder Calibration - Mean Peak Pressure, where

Source Level = 101.7 db//microbar at 1 yard,
Propagation Loss = 20 log 2D + 2aD,
Receiving Response = -70 db//1 volt/microbar,
Receiver Gain = 80 db,
Recorder Calibration (0 db) = -40 db//1 volt,
Peak Pressure = read from the record,
D = depth in yards, and
a = absorption coefficient = 1.1 db/kyd.

Table 1 Summary of reflection loss data

Station No.	Latitude (N)	Longitude (W)	Depth (fathoms)	No. of Reflections	Mean Loss (db)	Standard Dev. (db)
1	33°07'	73°06'	2760	24	15.6	3.6
2	33°10'	72°54'	2745	28	17.2	4.2
3	33°06'	72°15'	2800	27	23.3	4.2
4	33°05'	71°49'	2880	13	17.6	6.2
5	32°41'	71°48'	2850	25	20.9	3.5
6	32°36'	72°12'	2825	26	23.9	3.0
7	32°40'	72°37'	2800	25	26.0	3.5
8	32°39'	73°03'	2760	34	22.1	1.9
9	32°16'	71°53'	2840	28	20.6	4.9
10	32°12'	72°13'	2800	27	21.7	7.6
11	32°18'	72°42'	2820	15	21.3	3.9
12	34°04'	71°30'	2710	26	19.6	3.5
13	33°59'	70°59'	2808	26	16.5	2.6
14	33°40'	71°00'	2840	27	14.0	2.7
15	33°38'	71°29	2805	19	14.0	2.9

The reflection loss measurements were adjusted for attenuator settings and corrected for background noise when necessary. The average absorption coefficient for the water column was determined from the Marsh and Schulkin[3,4] equation for absorption. The data have been adjusted for several sources of error[5]. These errors result from the presence of nonspecular or scattered sound, tilting of the sound cone of the hull transducer due to ship motion, and deviation of the sounding velocity of 4800 ft/sec from the true mean velocity in the water column.

DISCUSSION

Mean reflection losses range from a low of 14 db at Stations 14 and 15 in the northeast to a high of 26 db at Station 7 in the southwest section of the area. The overall mean reflection loss for the area is 19.9 db. In general, the losses encountered in the northern section of the area tend to be about 4 db less than the losses in the southern half of the area (Fig 1).

Figure 2 illustrates fluctuations in reflection loss encountered during a 13-minute period at Stations 5 and 13. Figure 3 is a frequency distribution of reflection loss for

the entire area. While the fluctuations appear to be typical of the area, it is not known if they result soley from variations in the bottom or to what extent bottom scattering, internal fluctuations in the sound field, and pulse-by-pulse variations in the UQN sounding systems affect the measurements. The presence of these fluctuations, in this and other areas[2,6] emphasizes the reason for averaging reflection loss measurements. The discussion below is a possible explanation for the fluctuations based on bottom variations.

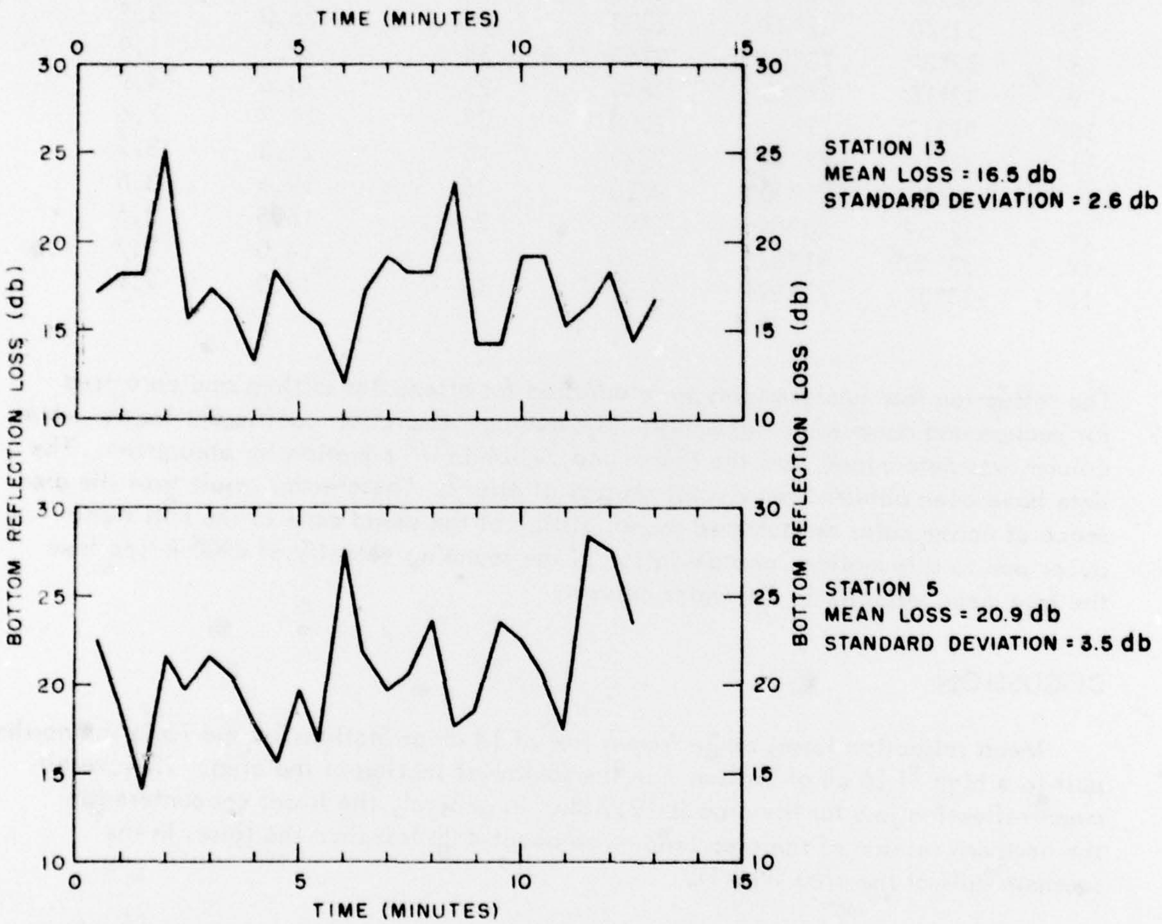

FIGURE 2 FLUCTUATIONS IN BOTTOM REFLECTION LOSS

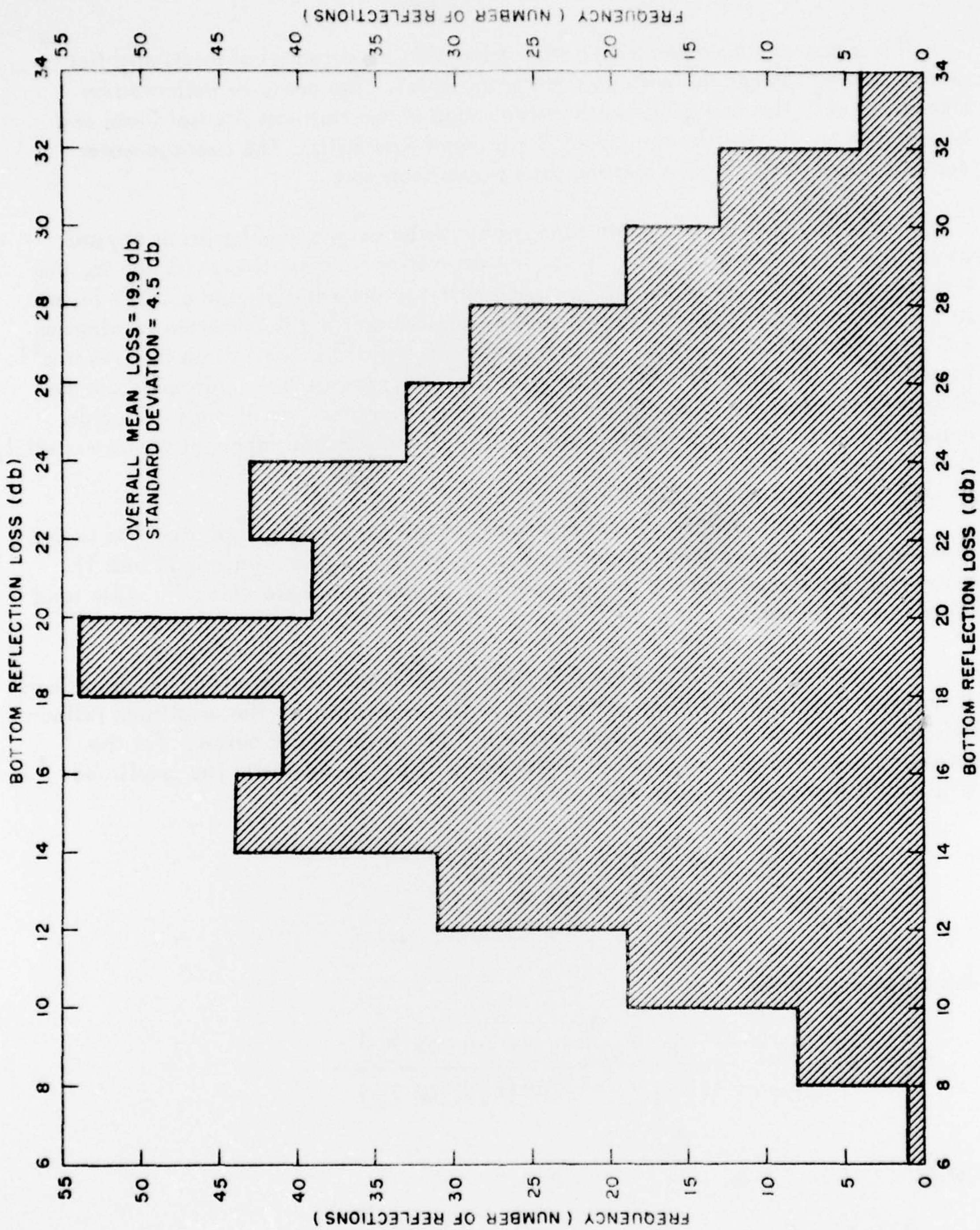

FIGURE 3 FREQUENCY DISTRIBUTION OF BOTTOM REFLECTION LOSSES

This area, as illustrated by the PDR echograms, is a region of relatively flat or gently sloping topography with no significant relief. The area, as indicated by Heezen et al[7], lies along the northwestern edge of the Hatteras Abyssal Plain and is bordered on the west by the Lower Continental Rise Hills. The average water depth is about 2800 fathoms and the area slopes southeast.

It is believed that the smooth topography of the deep ocean basins or abyssal plains is a direct result of turbidity current deposition. Supporting evidence for the turbidity current theory of deposition is found in the presence of sand and silt layers in cored sediments[8,9] taken in abyssal plain regions and in the numerous sub-bottom reflectors encountered during seismic reflection surveys[10] as well as on PDR records[11]. In general, sub-bottom reflections in abyssal plain areas are not continuous and may disappear in relatively short distances. However, the presence of these reflectors appears to indicate layers of increased rigidity[11] and possible layers of coarse material, such as sand and silt.

The source of turbidity current sediments in this area is the Cape Hatteras region to the north or possibly the Hudson Canyon. Cores taken near Stations 12 and 15 show well sorted sand and silt layers separated by brown and gray clay[10]. One sand layer was 58 cm thick.

It is possible to present a plausible three-layer model for investigating the effects of sediment layering on bottom reflectivity. The expression for the amplitude reflection coefficient was derived by Brekhovskikh[12] and is presented below. For the purposes of this report, only normal incidence will be considered. The amplitude reflection coefficient is given by

$$V = \frac{V_{23} + V_{12}\ \exp(2ik_2 d \cos \gamma_2)}{1 + V_{23} V_{12} \exp(2ik_2 d \cos \gamma_2)}$$

which can be written

$$V = \frac{(V_{23} + V_{12}) + i(V_{12} - V_{23}) \tan(k_2 d \cos \gamma_2)}{(1 + V_{23} V_{12}) + i(V_{23} V_{12} - 1) \tan(k_2 d \cos \gamma_2)}$$

where

$$V_{23} = \frac{Z_2 - Z_3}{Z_2 + Z_3}; \quad Z_2 = \frac{\rho_2 C_2}{\cos \gamma_2}; \quad Z_3 = \frac{\rho_3 C_3}{\cos \gamma_3};$$

$$V_{12} = \frac{Z_1 - Z_2}{Z_2 + Z_3} \; ; \quad Z_1 = \frac{\rho_1 C_1}{\cos \gamma_1} \; ;$$

$$k_2 = \frac{\omega}{C_2} = \frac{2\pi f}{C_2} \; ; \quad \rho = \text{DENSITY} \; ; \text{ AND } \; C = \text{VELOCITY.}$$

Bottom reflection loss in db may be expressed by

$$R.L. = 10 \; LOG_{10} \; |V|^2.$$

An illustration of the three-layer model is presented in Figure 4. It should be noted that Brekhovskikh's notations were maintained for continuity.

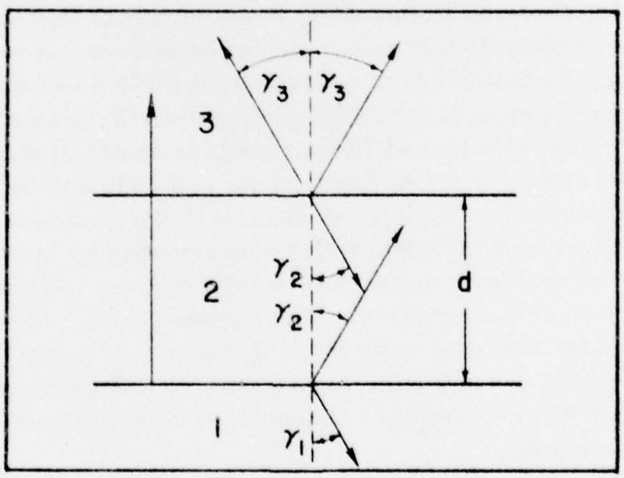

FIGURE 4 THREE-LAYER REFLECTION MODEL

Core analysis for this area has not been completed; however, it is known that sediment layering exists in the vicinity of the reflection measurements. The sediment density and velocity values used in this report are consistent with available data[13]. Layer 3 is assumed to be water of a constant density and velocity, and layer 2 is

considered to be a low velocity clay or fine-grained silt which overlies a layer (layer 1) of coarse silt or sand of higher acoustic impedance (ρc) than layer 2.

The assumed layering is consistent with existing conditions since the presence of low-velocity sediments just beneath the water-sediment interface has been detected by Katz and Ewing[14], while turbidity current deposition would account for the silt or sand layer.

Figures 5 and 6 depict the reflection coefficient and corresponding reflection loss for 3 instances in which the acoustic impedance of layers 1 and 2 was varied. From this it can be seen that variations in the acoustic impedance of layers 1 and 2 can account for fluctuations in the reflection coefficient and consequently in the theoretical reflection loss. However, even more significant is the effect upon the reflection coefficient of small changes in the thickness of layer 2. Maxima in each curve occur when the thickness of layer 2 is equal to one half wavelength. The reflection coefficient reaches a minimum value when the thickness of the center layer is equal to an odd number of quarter wavelengths. Reflection can be entirely eliminated when the acoustic impedance of the center layer is equal to the geometric mean of the impedances of layers 1 and 3 $\rho_2 C_2 = \sqrt{\rho_1 C_1 \rho_3 C_3}$.

Although the three-layer model offers a plausible explanation for the measured reflection losses encountered in this area, it would appear that this model should be extended to include absorption of sound within the sediment as well as additional sediment layering. Extension of the reflection coefficient to include absorption and additional sediment layering is necessitated by the verification of more than one sub-bottom reflector and penetration of 12-kc signals to depths of about 100 feet. Fry and Parker[15] have presented a four-layer model and Cole and Bell[16] have included absorption in the three-layer model. Mackenzie[17] has presented a modified two-layer Rayleigh reflection coefficient which was extended by Morse to include absorption. Since the two-layer model does not account for sediment layering, it would appear that an n-layer model should be investigated. The number of layers included in the model should be determined by the actual number of significant sediment layers present in long cores taken in the various physiographic provinces of the oceans. Sub-bottom reflectors encountered during seismic reflection surveys should also be considered.

COMPARISON WITH OTHER DATA

The overall mean reflection loss for the entire area is about 20 db, which is about 2 db higher than the corrected AMOS[18, 19] reflection loss curve for 12-kc and normal incidence. Brass II[20] reflection loss measurements made at grazing angles of

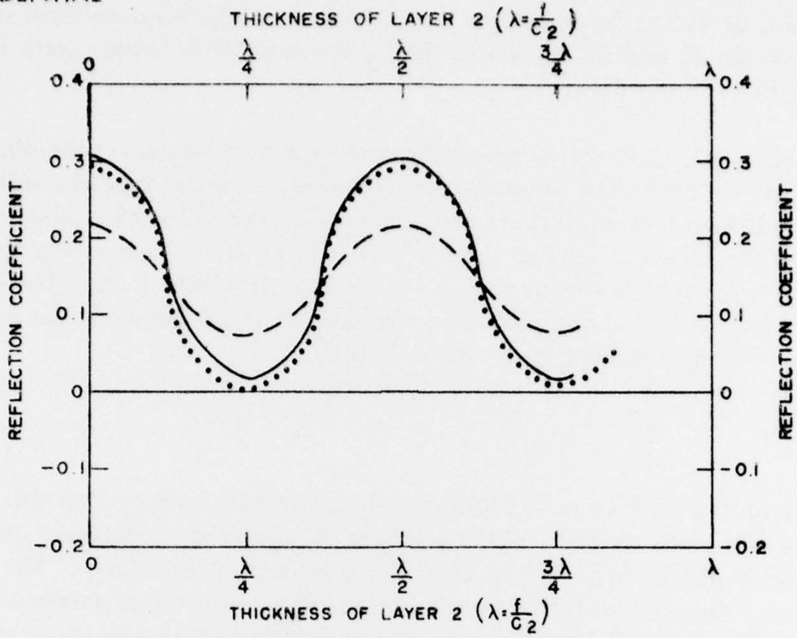

FIGURE 5 BOTTOM REFLECTION COEFFICIENT VERSUS THICKNESS OF LAYER 2

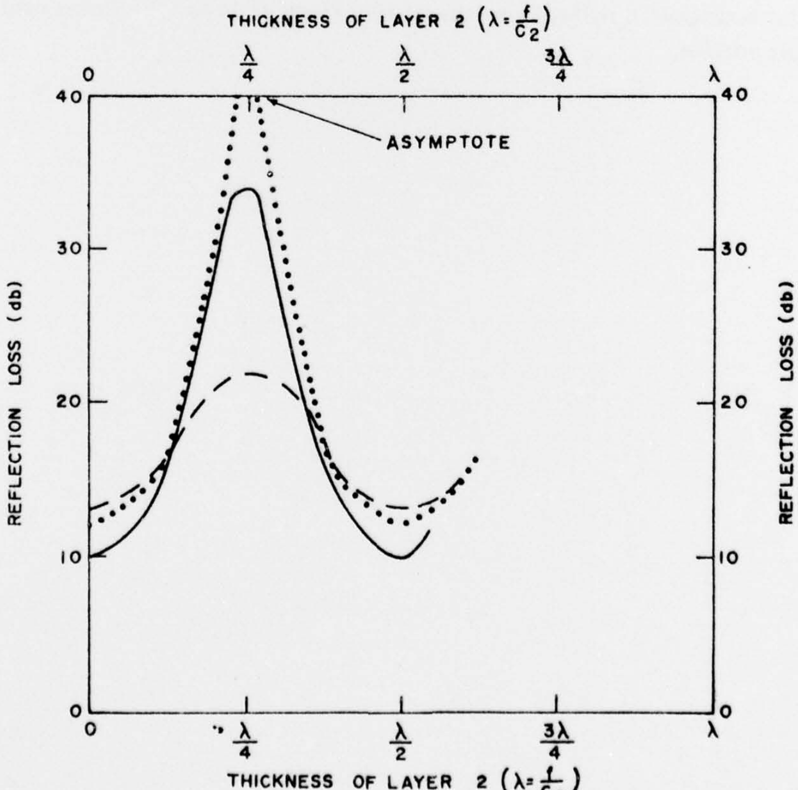

FIGURE 6 BOTTOM REFLECTION LOSS VERSUS 10 LOG $(V)^2$

20 to 30 degrees at 4.5 kc in an area about 75 miles east of this area show reflection loss values between 21 and 25 db, while similar measurements further north indicate losses ranging from 11 to 14 db.

Any comparison of reflection loss measurements is meaningless if the absorption coefficients used in the computations do not coincide. The average absorption coefficient determined from the expression presented in the AMOS report is about 0.2 db/kyd greater than the 1.1 db/kyd used in this report. By compensating for this difference it was found that the mean loss for the area is within 1 db of the corrected AMOS bottom loss for 12 kc and normal incidence. It is not known if the AMOS absorption coefficient was used in the Brass II study.

CONCLUSION

Normal incidence 12-kc reflection loss measurements indicate that this area may be one of variable reflectivity. Low loss values of 14 db show relatively good reflectivity, whereas high values of 24 and 26 db indicate poor reflectivity. The range of the Brass II losses coupled with the normal incidence measurements possibly indicates the variable sediment conditions that may be encountered in abyssal plain regions or in areas accessible to turbidity currents. A layered model may be used to explain theoretical fluctuations in reflection loss as functions of layer thickness and variations in sediment properties.

BIBLIOGRAPHY

1. COMDESDEVGRUPAC Sound Reflection Measurements in the Pacific, Prepared and submitted by Commander Destroyer Development Group Pacific, 29 September 1961. (CONFIDENTIAL)

2. Winokur, R. S. and Breaker, L. C., Reflectivity Measurements in Pacific Area G, U. S. Naval Oceanographic Office, IMR No. 0-101-63, January 1963, Unpublished Manuscript. (CONFIDENTIAL)

3. Schulkin, M. and Marsh, H. W., Letter on Absorption Constant, Journal Acoustical Society of America, vol. 34, No. 6, p. 864, June 1962.

4. Thompson, K. P., Determination of Absorption Constant, Memorandum for file, Naval Research Laboratory, August 1962.

5. Winokur, R. S., Reflectivity Measurements in Atlantic OPEVAL Area B, U. S. Naval Oceanographic Office IMR No. 0-102-63, January 1963, Unpublished Manuscript. (CONFIDENTIAL)

6. --- Reflectivity Measurements in Pacific Area H, U. S. Naval Oceanographic Office, IMR No. 0-107-63, January 1963, Unpublished Manuscript. (CONFIDENTIAL)

7. Heezen, B. C., Tharp, M., Ewing, M., The Floors of the Oceans, Geological Society of America, Special Paper 65, April 11, 1959.

8. Ericson, D. B., Ewing, M., Heezen, B. C., and Wollin, G., Sediment Deposition in Deep Atlantic, Geological Society of America, Special Paper 62, p. 205-220, 1955.

9. Ericson, D. B., Ewing, M., and Heezen, B. C., Turbidity Currents and Sediments in North Atlantic, Bulletin of the American Association of Petroleum Geologists, vol. 36, No. 3, p. 489-511, March 1952.

10. Hersey, J. B. and Ewing, M., Seismic Reflections from Beneath the Ocean Floor, Transactions of American Geophysical Union, vol. 30, p. 5-14, 1949.

11. Ewing, J., Luskin, B., Roberts, A., and Hirshman, J., Sub-Bottom Reflection Measurements on the Continental Shelf, Bermuda Banks, West Indies Arc, and in the West Atlantic Basins, Journal of Geophysical Research, vol. 65, No. 9, p. 2849-2859, September 1960.

12. Brekhovskikh, L. M., Waves in Layered Media, Academic Press, 1960.

13. Winokur, R. S., Acoustic and Physical Properties of Bottom Sediments, U. S. Naval Oceanographic Office, IMR No. 0-42-62, Unpublished Manuscript, May 1962.

14. Katz, S. and Ewing, M., Seismic Refraction Measurements in the Atlantic Ocean; Part VII. Atlantic Ocean Basin West of Bermuda, Geological Society of America, vol. 67, p. 475-510, 1956.

15. Fry, J. C. and Parker, F. D., Sound Reflection Profiles Across the North Pacific, Journal Underwater Acoustics (USN), vol. 12, No. 4, p. 781-790, October 1962. (CONFIDENTIAL)

16. Cole, B. F. and Bell, T. G., Three Layer Fluid Model for Ocean Bottom Reflectivity, Underwater Sound Laboratory, Tech. Memo. No. 905-55-62, December 1962.

17. Mackenzie, K. V., Reflection of Sound from Coastal Bottoms, Journal Acoustical Society of America, vol. 32, No. 2, p. 221-231, February 1960.

18. Marsh, H. W. and Schulkin, M., Report on the Status of Project AMOS, U. S. Navy Underwater Sound Laboratory, Report No. 255, March 1955. (CONFIDENTIAL)

19. Bell, T. G., A Theoretical Comparison of the Bottom - Bounce Capabilities of AN/SQS-23 versus AN/SQS-26 Surface Ship Sonars, U. S. Navy Underwater Sound Laboratory, Research Report No. 449, October 1959. (CONFIDENTIAL)

20. Wilms, H. J., Experimental Bottom-Bounce Echo-Ranging Results, U. S. Navy Underwater Sound Laboratory, Research Report No. 499, December 1960. (CONFIDENTIAL)

64 223-0281